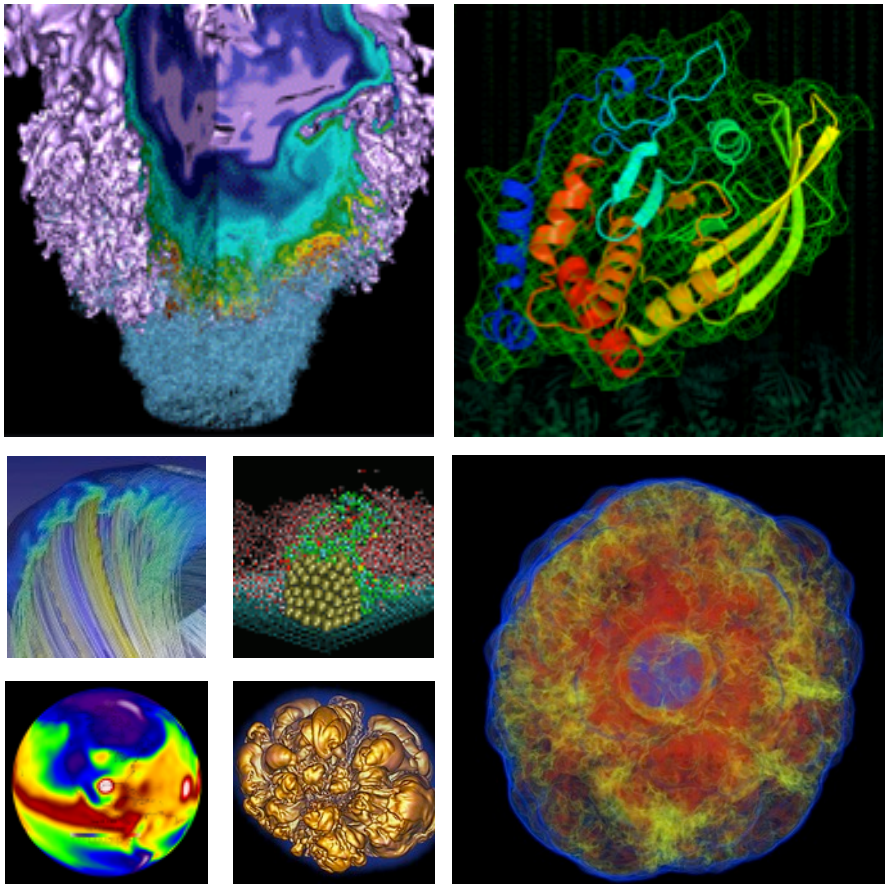
Using Craypat & Reveal on Cori



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Outline

I. Profiling with Craypat

II. Using Reveal for OpenMP

I. PROFILING WITH CRAYPAT

Profile of Cochise in the Chiricahua Mountains by Ken Bosma, http://www.flickr.com/photos/kretyen/2879059366/

I. Profiling with Craypat

- Introduction
- Simple profiling
- Full-service profiling

Introduction

- **Craypat is Cray's Performance Analysis Tool**
- **Evaluate program behavior on Cray supercomputer**
  - Under any PrgEnv
- **Find hotspots, load imbalance, inefficiencies**
  - I/O, memory usage
  - MPI communications
  - Flops
  - Recommendation for rank reordering (sometimes)
- **Profiler with limited tracing abilities**
  - Tracing tools with better performance: MAP, VampirTrace

Simple Profiling with CrayPat

- **`perftools-lite` module easier to use & does (almost) everything in `perftools`**
- **Compile code with `perftools-lite` module loaded**
- **Run code as normal**
- **Output:**
  - Stdout & `*.rpt` file: report with execution time, memory high-water mark, aggregate FLOPS rate, top time-consuming user functions, MPI info, etc.
  - `*.ap2` file: can be viewed with Apprentice 2
  - (Possibly) `MPICH_RANK_REORDER` file

Example Output (Preamble)

```
CrayPat/X:  Version 6.4.0 Revision bc8f5bd  05/24/16 17:52:13
Experiment:                    lite  lite/sample_profile
Number of PEs (MPI ranks):       64
Numbers of PEs per Node:         64
Numbers of Threads per PE:        1
Number of Cores per Socket:      68
Execution start time:  Thu Oct 13 09:30:31 2016
System name and speed:  nid04403  1401 MHz (approx)
Intel knl CPU  Family:  6  Model: 87  Stepping:  1
MCDRAM: 7.2 GHz, 16 GiB available as quad,  flat (  0% cache)


Avg Process Time:    558.16 secs
High Memory:        1,899.7 MBytes     29.7 MBytes per PE
I/O Read Rate:     4.032070 MBytes/sec
I/O Write Rate:    3.618872 MBytes/sec
```

Example Output (Function Performance)

Table 1: Profile by Function Group and Function (top 10 functions shown)

Samp%	Samp	Imb. Samp	Imb. Samp%	Group Function PE=HIDE
100.0%	55,700.3	--	--	Total
49.3%	27,466.0	--	--	ETC
15.6%	8,679.3	1,276.7	13.0%	__cray_HCOSS_01
12.2%	6,821.2	1,167.8	14.8%	__cray_COS_V_01
8.9%	4,948.8	581.2	10.7%	_COS_Z
2.3%	1,285.3	335.7	21.0%	gotoblas_daxpy_k_knl
1.9%	1,071.1	235.9	18.3%	gotoblas_blas_memory_alloc_knl
1.9%	1,039.9	185.1	15.3%	gotoblas_dger_k_knl
35.5%	19,747.6	--	--	USER
23.0%	12,803.4	1,592.6	11.2%	intgrd_
7.6%	4,229.4	1,033.6	20.0%	dfshre_
3.1%	1,707.7	501.3	23.1%	drlhre_
14.7%	8,169.4	21,597.6	73.7%	MPI
14.7%	8,169.4	21,597.6	73.7%	MPI_Recv

Simple Profiling Recipe

- **Load/unload modules:**
  - `module unload darshan`
  - `module load perftools-base perftools-lite`
- **Compile and run your code as usual**

Full-Service Profiling

- **Motivation:**
  - Need more info than perftools-lite provides
  - Want to ignore certain subroutines
  - Focus on particular class of functions
  - Tracing rather than profiling
- **Super-deluxe profiling recipe**
- **pat_build options**

Super-Deluxe Profiling Recipe (1)

- **Load/unload modules:**
  - `module unload darshan`
  - `module load perftools-base perftools`
- **Compile code as usual, making sure to preserve object files**
- **`pat_build -O apa myapp`**
  - Generates executable called `myapp+pat`
- **Run `myapp+pat`**
  - Results in output file with name like `myapp+pat+######.xf` or directory called `myapp+pat+######`

Super-Deluxe Profiling Recipe (2)

- **`pat_report myapp+pat+*.xf`**
  - Generates `myapp+pat+*.apa`
- **`pat_build -O myapp+pat+*.apa`**
  - Generates executable called `myapp+apa`
- **Run `myapp+apa`**
- **`pat_report myapp+apa+*.xf`**

`pat_build` Options

- **`pat_build -O apa myapp`**
  - Craypat output for `myapp+pat` will be sampling to determine which subroutines can be ignored in full run. Additional file, `*.apa`, produced from `pat_report`
  - After this run, `execute pat_build -O *.apa` file to re-instrument `myapp+pat` into `myapp+apa` and run `myapp +apa` to get performance info
- **`pat_build -g tracegroup myapp`**
  - *`tracegroup`* is group of functions that can be automatically traced by CrayPat. Options include: `blas`, `fftw`, `mpi`, `netcdf`, `petsc`
- **`pat_build -w myapp`**
  - Do tracing experiment instead of profiling

II. PARALLELIZATION WITH CRAY REVEAL

“Happiness Revealed,” by Leonard Farshore, https://flic.kr/p/9z7isd

Cray Reveal

- Tool for porting to shared-memory or offload programming models
- Combine profiling info from Craypat and Cray compiler annotation to determine where to place OpenMP directives (generated automatically)
- Works ONLY with Cray programming environment

Using Cray Reveal

1. Compile code with Craypat instrumentation and create program library
2. Run representative job
3. Run Reveal
4. Insert directives, consider loop reordering, and analyze performance from optimizations

Cray Reveal Recipe (1)

- **Load/unload modules:**
  - `module unload darshan`
  - `module swap PrgEnv-intel PrgEnv-cray`
  - `module load perftools-base perftools`
- **Compile & link with**
  - `-h profile_generate` (to instrument), and
  - `-h pl=/directory/path/myapp.pl` (for compiler feedback)
- **Instrument binary for tracing:**
  - `pat_build -w ./myapp`
  - Creates instrumented application: `myapp+pat`

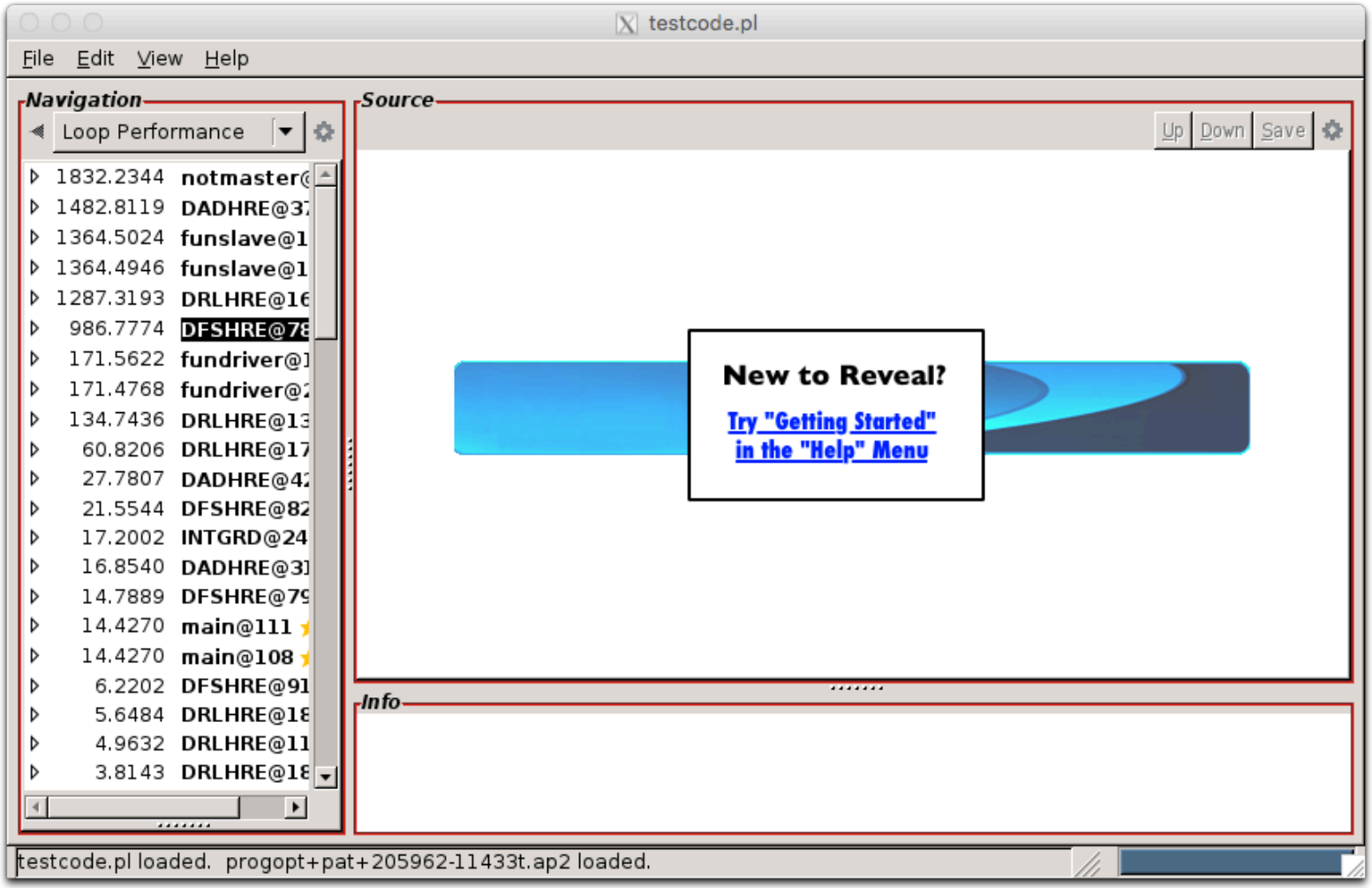
Cray Reveal Recipe (2)

- **Run instrumented application (`myapp+pat`) as normal**
  - Ideally this is job requiring 5-15 mins runtime, performing important subroutines in similar proportions to typical run
- **This creates file called `myapp+pat+########-##t.xf` (or directory `myapp+pat+########-##t/` for large runs)**
- **Create report with loop statistics**
  - `pat_report myapp+pat+* > loops_report.txt`
  - Generates `.ap2` file & generates text report in output file

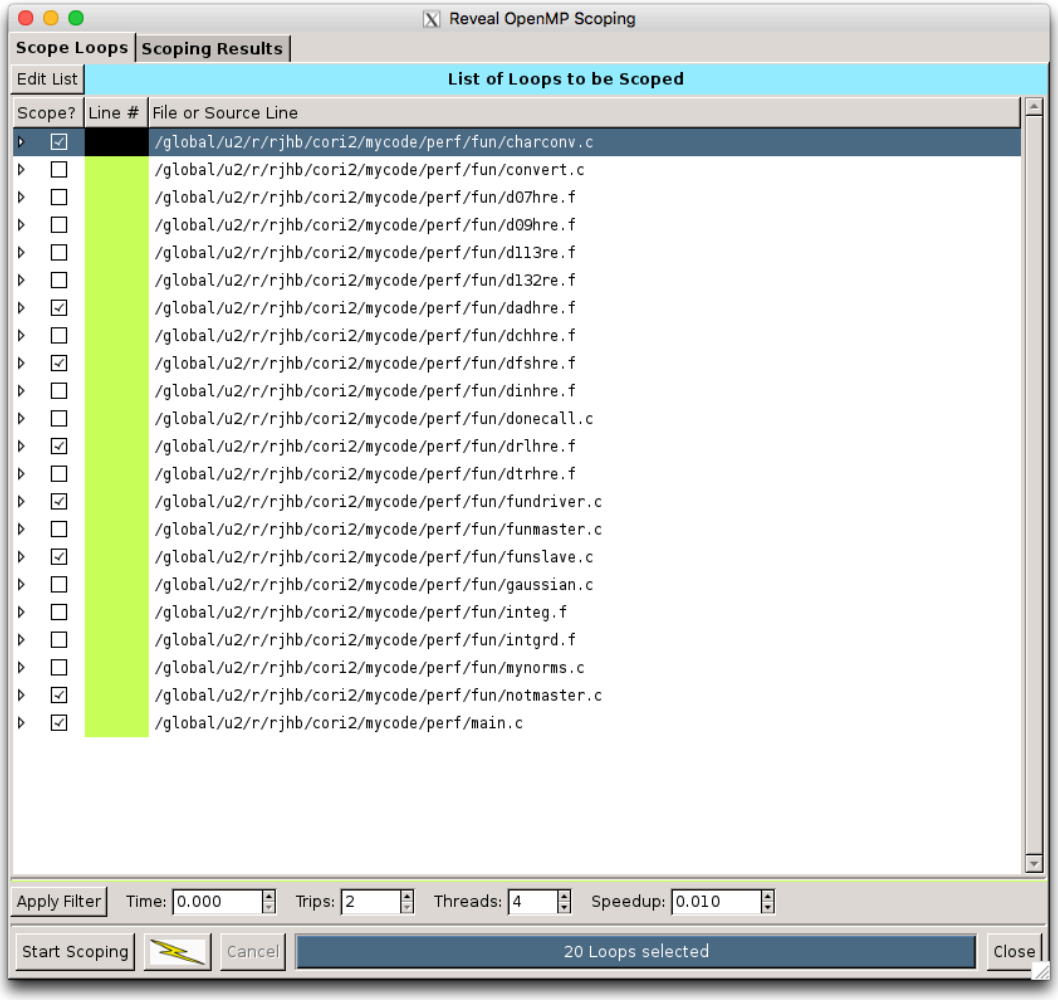
Cray Reveal Recipe (3)

- **Run Reveal**
  - `reveal /directory/path/myapp.pl` (compiler info only)
  - `reveal /directory/path/myapp.pl myapp +########+##t.ap2` (compiler + profiler info)

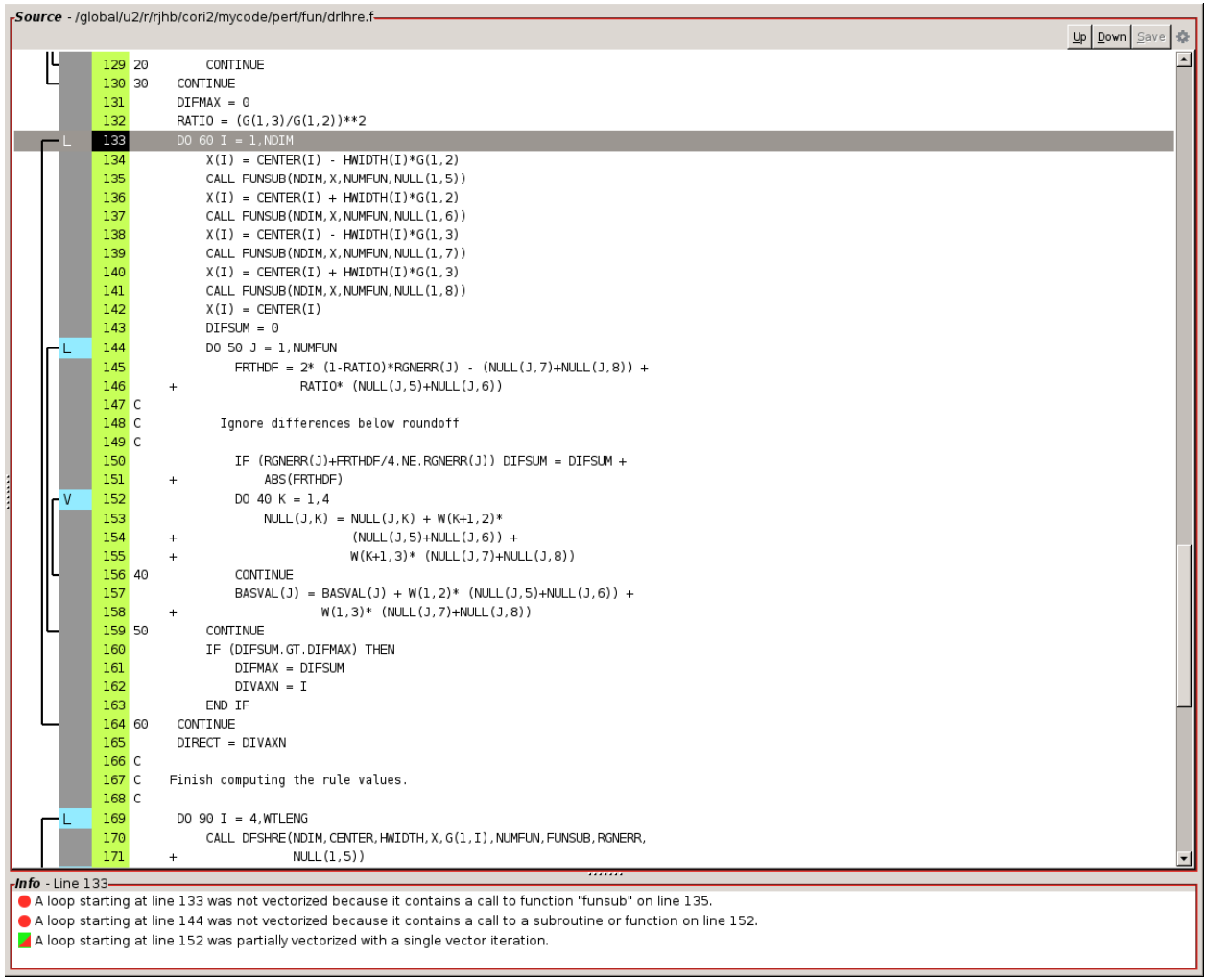
Opening Screen



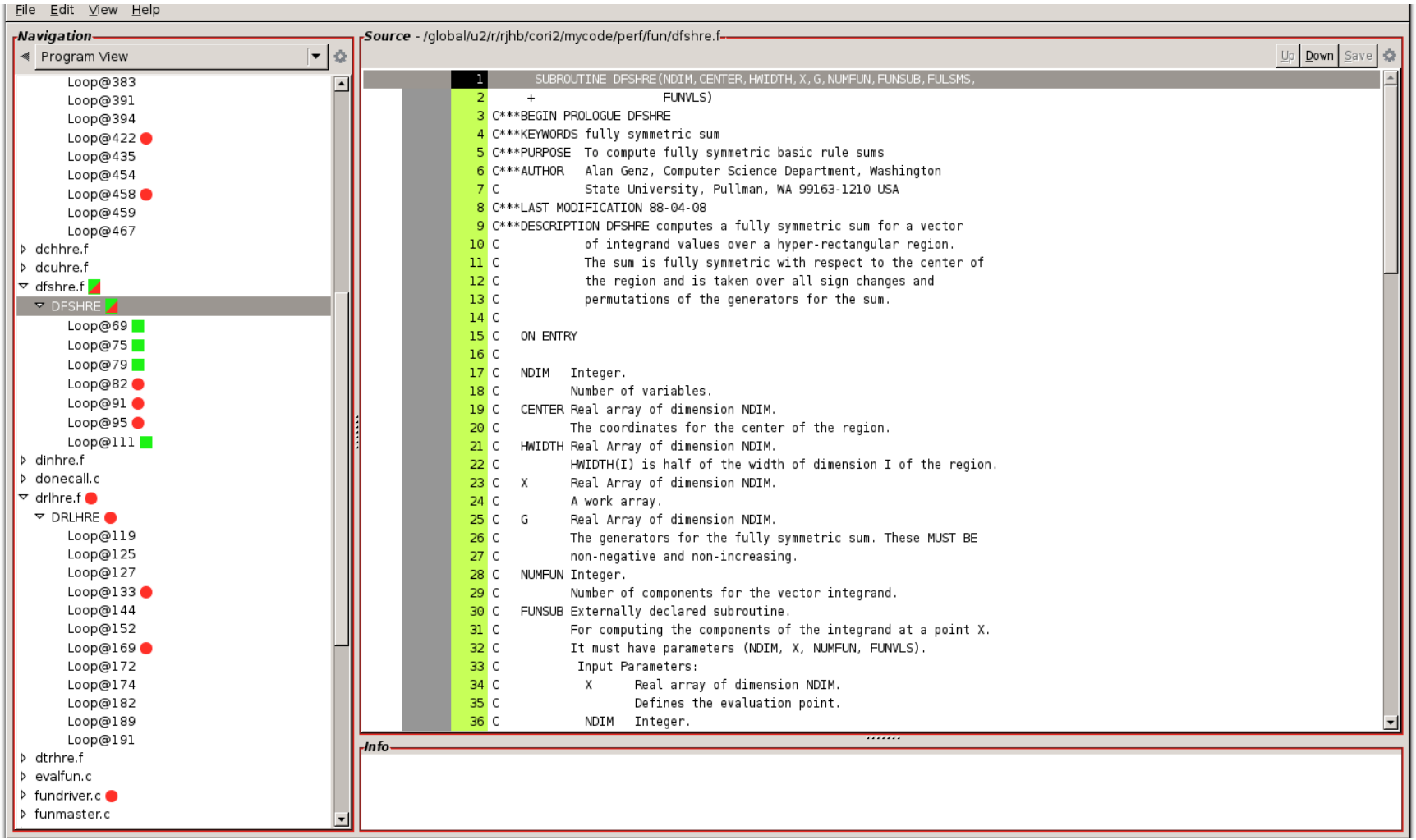
Scoping Window



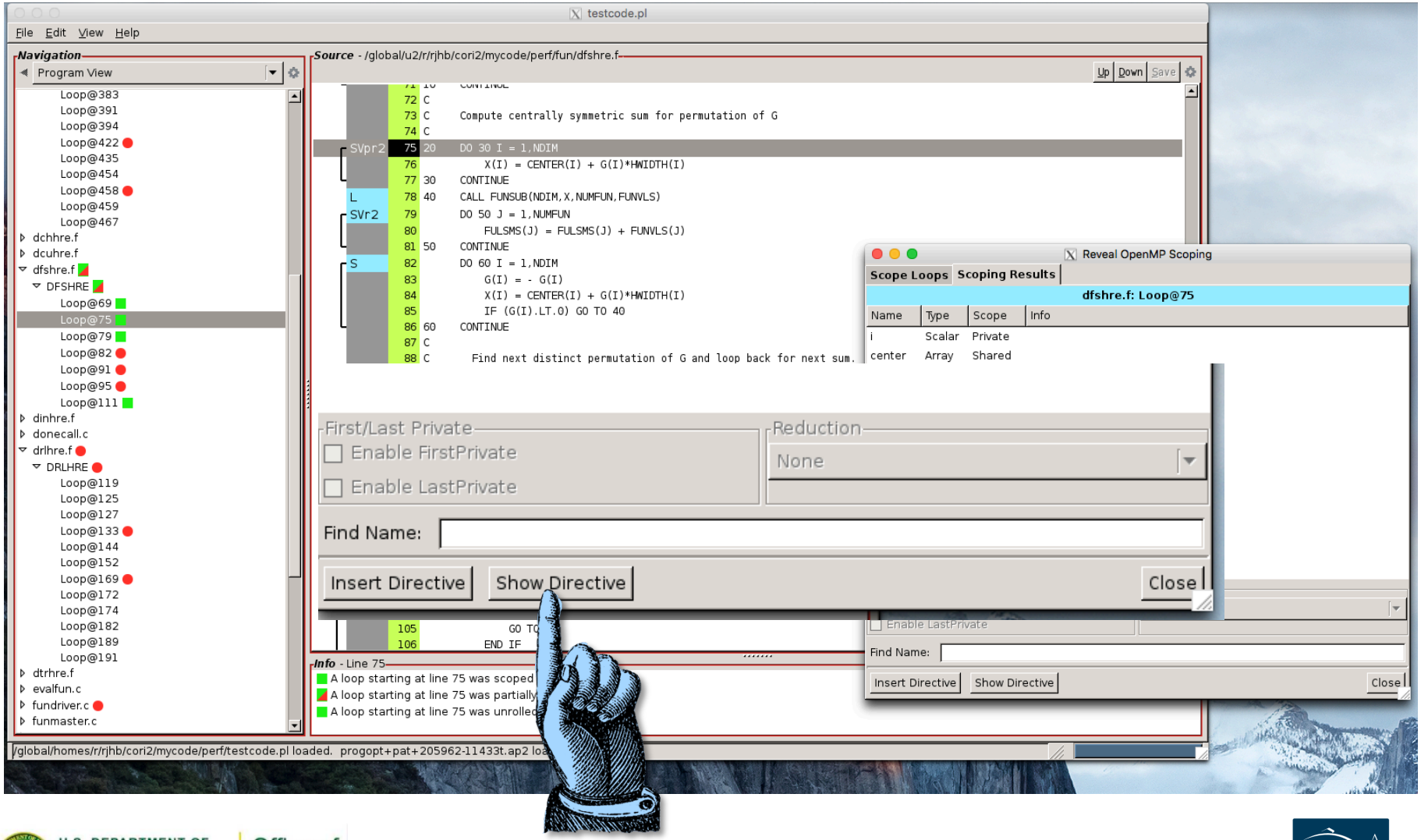
Compiler Annotations & Explanations



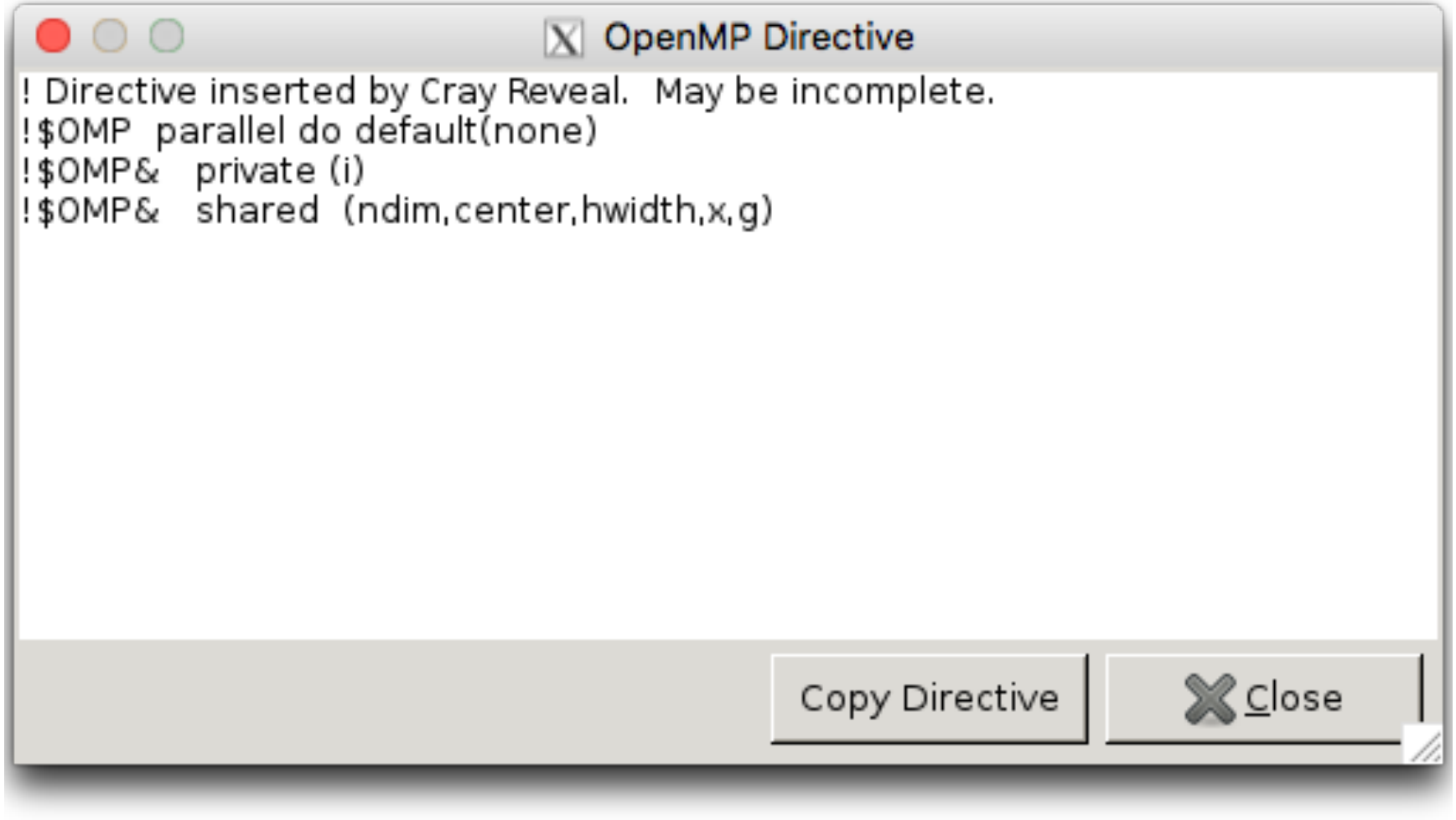
Partial Success in Subroutine



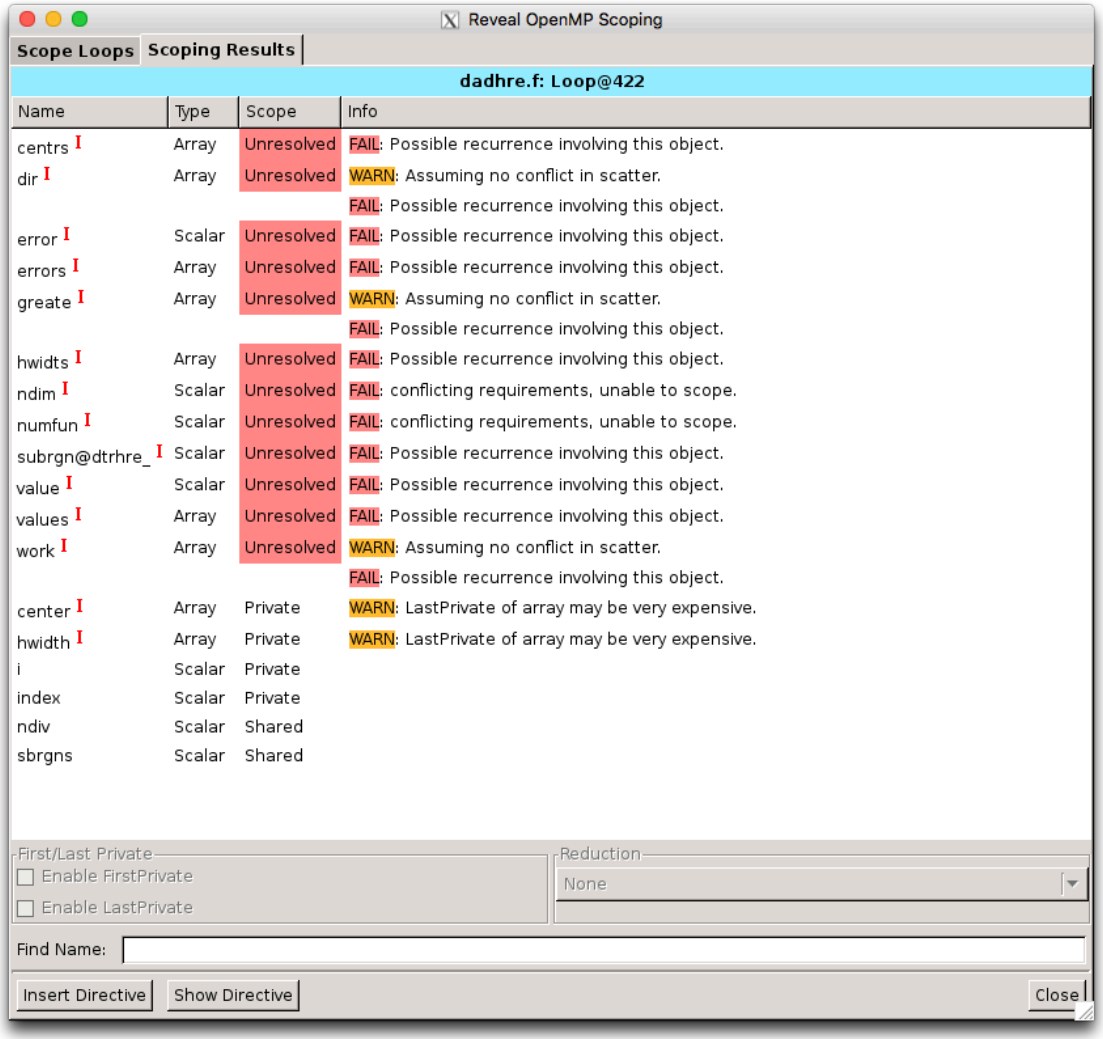
Successful Scoping



Directives Generated by Reveal



Unsuccessful Scoping



Unsuccessful Scoping Directive

Cray Reveal Recipe (4)

- **Insert directives**
- **Examine compiler feedback to determine potential loop reordering**
  - E.g., row- vs. column-ordered memory access patterns
  - Moving conditionals outside of loops
  - Cray compiler good at loop optimizations but requires some human help at times
- **Analyze performance after optimizations**
  - (Lather, rinse, repeat)

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